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Color of Life

E. John DeWaard • Illustrated by Jennifer Perrott

Living Things of The World

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De Waard
Color of life

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LIVING THINGS OF THE WORLD

The Color of Life

by

E. JOHN DEWAARD

Illustrations by Jennifer Perrott

Doubleday & Company, Inc., Garden City, New York

By the same author

PLANTS AND ANIMALS IN THE AIR

THE SHAPE OF LIVING THINGS

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Chapter 1

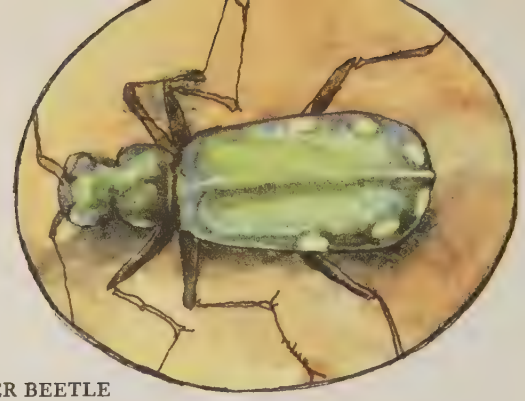
Colorful Life

Across the hills and valleys of the Northern Temperate Zone lands, the air turns chill. The oaks, maples, and beeches of the forests glow with brilliant colors, making the landscape a breath-takingly beautiful sight. It is autumn.

Yet it is no more beautiful than the myriad colors displayed by the desert flowers which bloom after the first spring rainfall. The cacti are especially beautiful. Most of the year these plants are a dull green or brown. But, with the first gentle caress of a spring rain, they burst into color. There are the scarlet flowers of the torch cactus, the yellow blooms of the prickly pear, the delicate pink flowers of the Mexican rose, and the deep-purple blooms of the cane cactus.

Equally as colorful are the insects which visit flowers in the tropics. Exquisite moths whose furry bodies bear wings that are shingled with glowing scales of rose, green, blue, and brown, flit from blossom to blossom. Bright flower beetles hide in the depths of a flower, their colors blending with those of the blossom.

URANIA MOTH



TIGER BEETLE

And the golden-colored bees and metallic-hued wasps flash in the sunlight as they come to gather nectar and pollen.

Among the animals are many which can change their colors. Tree toads can change from russet brown through white to emerald green within a short time. This ability allows the toad to blend into its background.

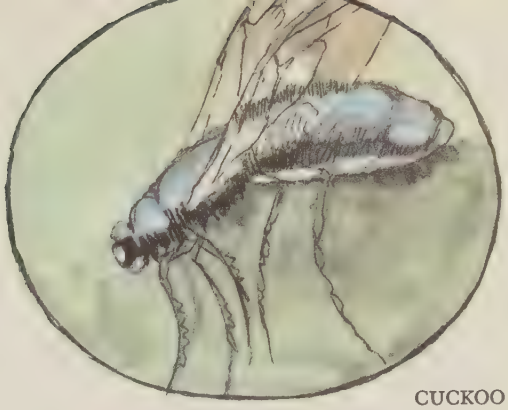
Other animals also change coat color but very gradually. Furred creatures often grow seasonal coats. In spring, dark fur enables the animal to hide in the deep shadows of the forest. As the seasons change and the air grows cooler, the dark hairs drop out and white hairs grow in. Changes in coat color occur most often in regions where winter is prolonged and there is much snow. Some of these animals grow winter coats under the summer fur. When the chill winds of late autumn howl down out of the north, the dark hairs fall out. In a matter of only a few days, the animal turns white.

Some animals have coats which remain unchanged throughout the year. Everyone is familiar with the beautiful color and pattern of the tiger's coat, the rich brown fur of the mink, and the characteristic black-and-brown spots of the leopard.

SUMMER

AUTUMN

AGRIAS BUTTERFLY



CUCKOO WASP

Man has long considered such colors and patterns highly desirable. Many domestic animals have been bred exclusively to maintain a particular color characteristic, such as the Siamese cat with its chocolate or seal point markings.

Such interbreeding is even more remarkable among garden flowers. The tulip has a long and fascinating history. It was discovered growing wild in Persia by the armies of Alexander the Great. In the early sixteenth century, bulbs of this lovely pale flower were brought to the Netherlands. Dutch gardeners developed new strains with brilliant flowers. Thus, from the simple cream-colored wild tulip came all the brilliant blossoms we know today—the Red Emperor, the pink parrot and, darkest of all, the Darwin tulip which is almost black.

The rose is another garden flower which growers have bred to unusual colors. One of the newest strains has lilac-colored blossoms. Still another type of rose has petals which are red on one side and yellow on the other. Orange and coral were once unknown rose colors. Today they are common and popular hues, thanks to the work of scientific rose growers.

Yet it is not plants alone which are gaily colored. Among the

WINTER

SPRING

The bright-hued flowers in our gardens are the result of hundreds of years of careful breeding.

small gray birds of winter which visit our feeding stations, there can appear a flash of color. A streak of red across the snow, a fluttering in the evergreens; wherever the male cardinal is, nothing can hide his bright plumage.

But it is in the tropics that the most brilliant birds are found—macaws and parrots with exotic colors that rival the rainbow, and the bird of paradise with hues that delight the eye. Yet perhaps the flamingo is the brightest of all. No one can really describe the feathers of a flamingo. Even when one sees the bird, the rose-pink color looks unreal—as if the bird had been dyed like some Easter chick. But there it is before you, preening its pink feathers while resting on one long pink leg like a character from some fairy tale come to life.

Many birds have seasonal colors. They wear bright hues during the spring-mating season. Then they molt in late summer, growing a drab winter coat. The bobolink is one of these.

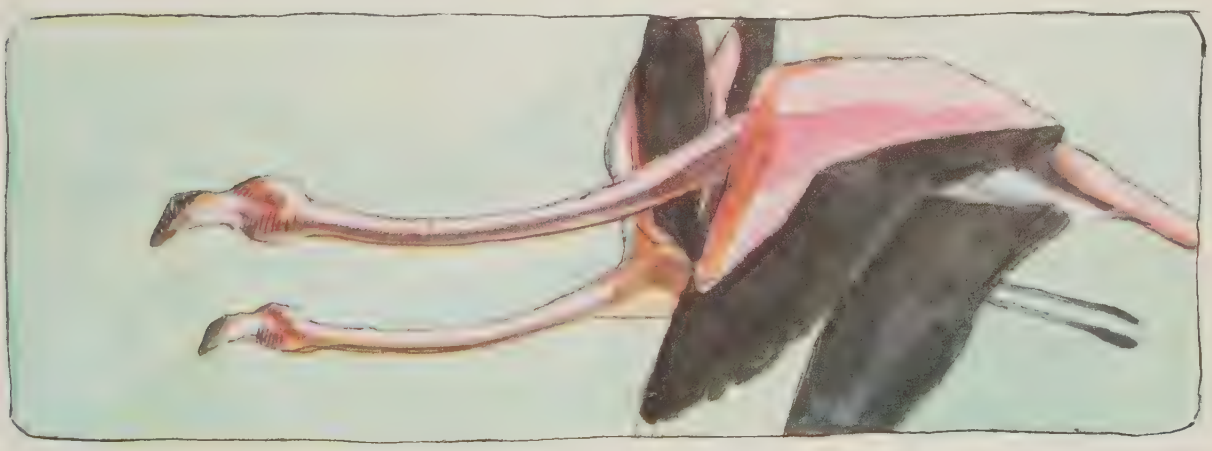
Another interesting phenomenon of the bird world is the young birds that acquire a kind of intermediate plumage. Such a bird is the American bald eagle. Young eagles are almost black until they are a year old. Then, during the second year, they appear gray. Finally, when they reach the age of three years, their

heads and tails become white. These contrast sharply with their bodies and wings of gleaming black.

For centuries, man was content merely to admire and imitate the colors found in nature. Not until recently have scientists become interested in the reasons why various colors appeared in living things.

Now men are seeking answers to questions such as: Why is there such a variation of skin color among the peoples of the world? Why do autumn leaves turn scarlet and yellow? Why are green plants green? How are certain animals able to change their skin color so rapidly?

Many of these questions have not yet been answered completely. What scientists have learned, however, is that there may be reasons for the beautiful colors found in life. Color in life is not, as we might think, merely for the sake of beauty.



FLAMINGO

COCK OF THE ROCK

BIRD OF PARADISE

SEA GULLS

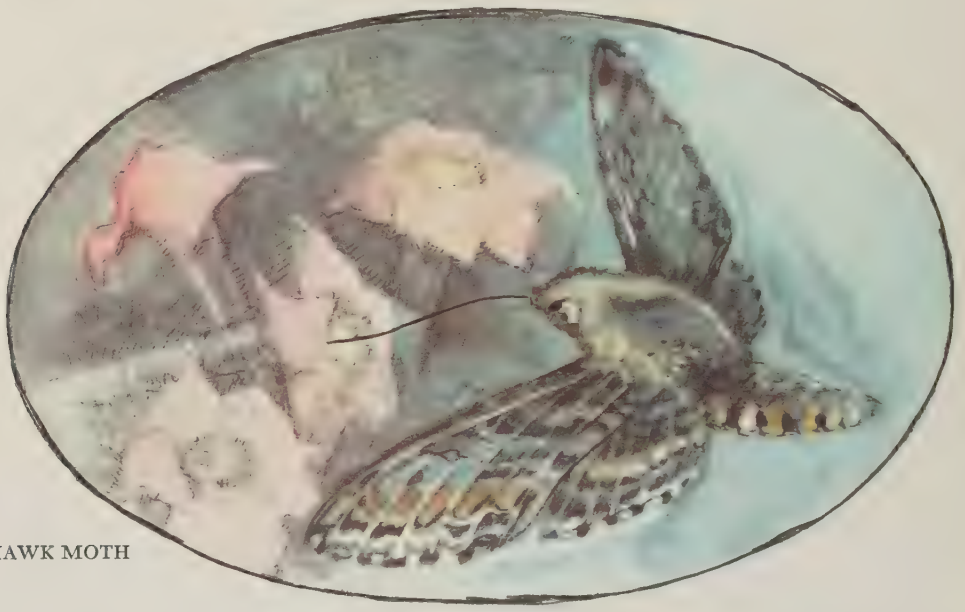
Chapter 2

The Color of Attraction

On a cliff high above the breaking waves of the Atlantic, a gull broods its eggs. Within a few moments, strange movements in the eggs cause her to leave the nest. The chicks are beginning to hatch. Pushing with the strong movement of a special neck muscle, the young birds knock a hole through the imprisoning shell. They emerge, weak from the struggle. But after a few hours in the warmth of the sun and their mother's breast, they become dry and fluffy. Then they begin to make strong pecking movements at a red spot on the parent's beak. The parent bird responds to this pecking by feeding the young.

Perhaps pecking is instinctive in young birds. Scientists wondered about this and so they tried an experiment. A black-headed gull was hatched in an incubator. The chick was kept in complete darkness for several hours. Then it was exposed to several models of an adult's beak. Some had spots of yellow, some black, some white, and one red. Always the chick responded most eagerly to the red-spotted model. Clearly, to the tiny chick the color of attraction was red.

Color is important in being attractive. And being attractive is often necessary to survival. *Nicotiana* is a night-blooming flower with a long slender throat. It must be pollinated by night-flying insects such as moths. The flowers of *Nicotiana* are of delicate pastel hues. The pale pink, lavender, and white blooms are easily seen at night. Other flowers such as yucca, evening primrose, and phlox also must be pollinated by moths. They, too, are pale in color.



HAWK MOTH

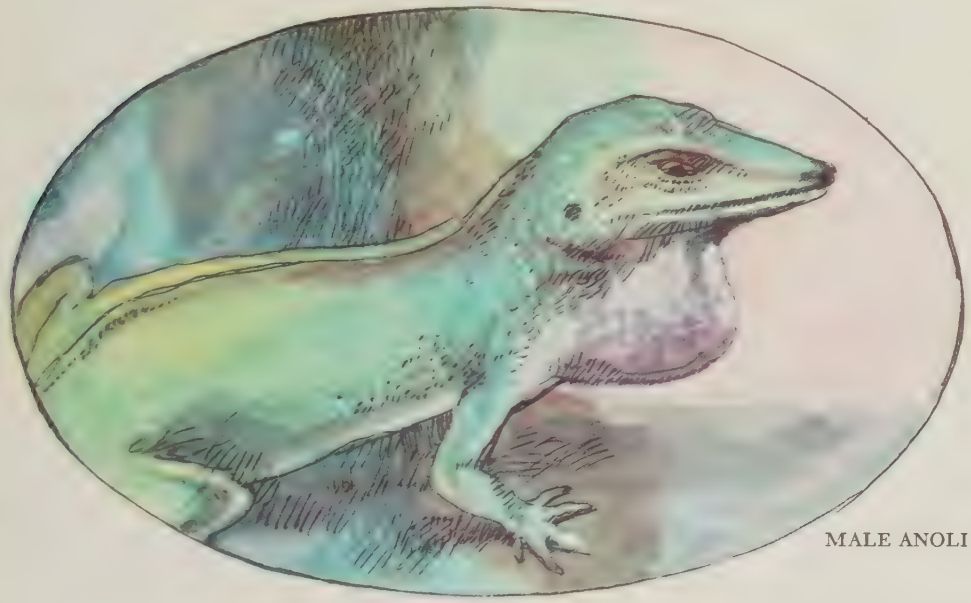
Flowers which bloom during the day attract other kinds of insects. Such plants as Indian paintbrush, many of the lilies, and those which bear flowers in the orange-red range of color attract butterflies. These colors are very visible to insects during the bright sunny hours.

Bees seem to be most attracted to flowers of blue or yellow color. Buzzing from flower to flower, the bee is particularly fond of larkspurs, snapdragons, and clover.

Other creatures use color to frighten enemies. Among these animals is a small brown lizard called the anole. Normally, its dull color enables it to hide securely in the trees where it feeds. But beneath the throat of the male lizard is a loose flap of skin colored

a bright lavender. At mating time, this flap of skin can be flared out into a brilliant purple fan.

Dancing fiercely and with fan outspread, the lizard assumes what is, to humans, a most unearthly look. But it is very attractive to female anoles. Soon a female comes to the male and they mate. However, the fan and aggressive posture can also serve another purpose. It is also used to frighten rival males away. Gesturing fiercely, it turns into a battle of who can scare whom.



MALE ANOLI LIZARD

Another splash of color in the lizard world is the blue-tailed skink. While most of the body of this animal is an unnoticeable gray-brown, the tail is sky blue. As the skink runs about the forest floor, the first thing a hungry predator sees is this tail. But as soon as the enemy pounces, the bright-blue tail breaks off, leaving the skink to scurry away—tailless but unharmed.

Among the birds, color acts as a lure to would-be enemies. The male bird is usually more brightly plumed than the female. Shimmering plumes of blue and green cover the peacock's head and breast. But even more breathtaking is its fan-shaped tail. Glinting in the sun, each tail feather is resplendent with a glimmering golden "eye." Proudly, the haughty male struts through

The shimmering plumes of the male peacock outshine the dingy colors of his mate.

the zoo. The hen, however, is dull brown with none of the exotic coloring of her mate.

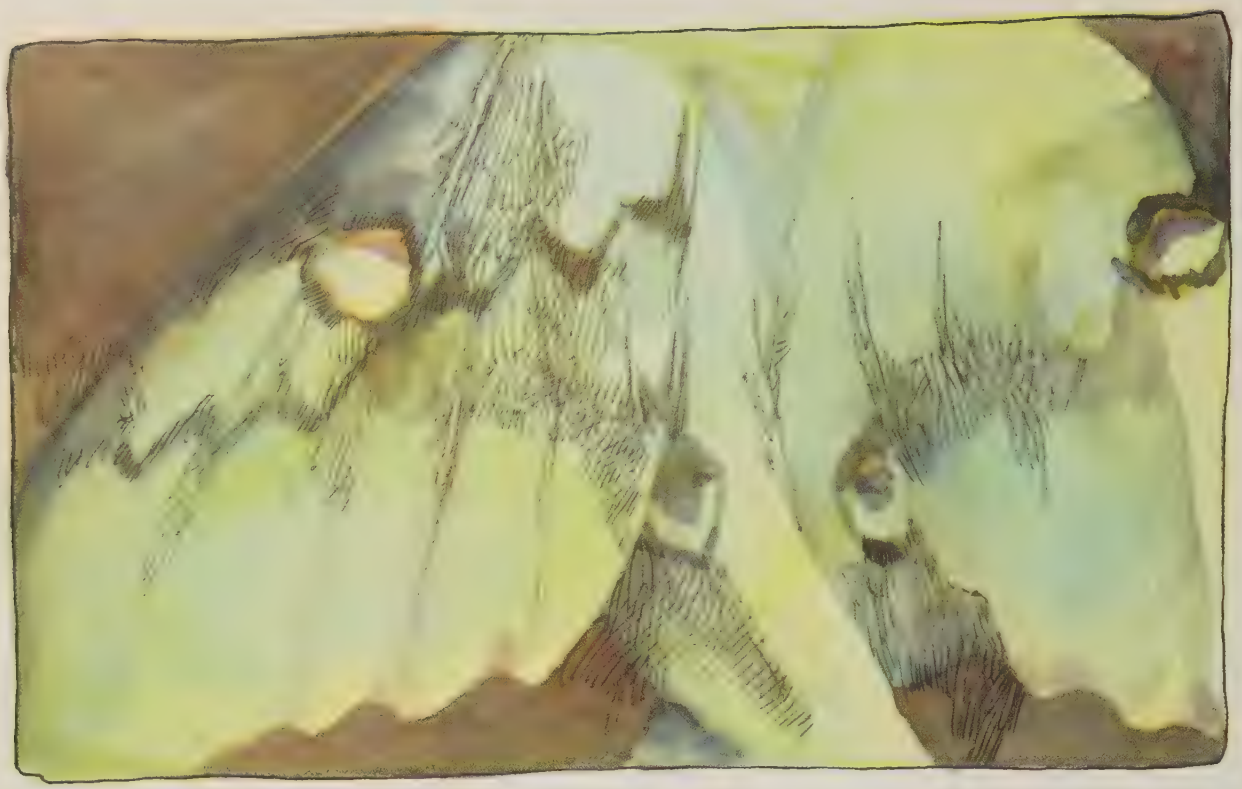
This is almost always true in the bird world. The male is usually brighter in color than the female. Sitting quietly on her nest, amid the flickering leaf patterns, the female is less likely to be seen. Thus, the female and chicks have a better chance to survive.

The brighter colors of the male bird are far more apt to catch the eye of an enemy such as a cat. He is then able to draw the hungry predator away from the nest. A chase through the brambles and the cat is left lashing its tail in frustration.

Among other birds, however, bright colors serve simply to attract a mate. The weird-looking frigate bird of the Galapagos Islands is one of these. The male bird has a large, red pouch beneath its beak. During courtship, the pouch is inflated. The bright-red color of the inflated pouch makes the bird look as though it is carrying a balloon. Strutting proudly, the male stalks the nesting area until a female notices his elegance and they mate. After the nest is built, the pouch deflates. Then the bird looks only as though it had red wattles.

Fish have also adopted color as a means of attraction. The angler fish has a threadlike projection growing on its head. Dangling from this is a reddish flap of skin which it jiggles much like a fishing worm. Other fish, tempted by this delicious-looking morsel swim close and cautiously eye it. Finally one darts in to sample it. But the waiting jaws of the angler are too quick for it. In a flash the hunter becomes the meal.

The alligator snapping turtle lures fish to its mouth by dangling a lure in front of them.



LUNA MOTH

Man has always been fascinated with the beauty around him. In fact, man grows many living things simply because they are beautiful. Almost everywhere that man lives, he cultivates flowers. In the Orient, butterflies and other insects are raised in order to delight the eye of collectors.

The moths and butterflies are among those insects that are most noted for exquisite coloring. On a misty spring evening, in a sheltered, lighted area, such as a porch, will perhaps be found one of the most beautiful moths of North America—the luna moth. Like a bit of fragile green tissue, it clings to the wall. Pink markings delicately trace the edge of its wings and the eye markings. Its size is amazing. It is almost as large as a human hand. If we approach it carefully, it can be picked up. But one false move and it will flutter off into the night.

Most brilliant of all insects are the tropical butterflies of South America and Southeast Asia. The South American callithea butterflies are among the most dazzling of all. As this insect flits

CALLITHEA BUTTERFLIES

SWALLOWTAIL BUTTERFLY

through the shifting light and shadow of the jungle, its wing colors vary with the light. At one moment it is a brilliant sapphire blue. But as the wings rise and fall, the color flickers from deep purple to pale turquoise. And the undersides of the wings are marked with a streak of red which contrasts beautifully with the jewel-like blues.

The tropics, however, do not have all of the bright butterflies. In North America, the tiger swallowtail, the zebra swallowtail, and the monarch are common insects. As they flash through the bright summer sun, they reflect a rainbow of color from the canary yellow of the tiger swallowtail to the deep orange-red of the monarch.

Thus, color not only attracts, but also delights man. It is truly as the poet Emerson once wrote:

". . . if eyes were made for seeing,
Then Beauty is its own excuse for being."

Chapter 3

The Color of Protection

Early spring has begun to change the meadow. New grass is beginning to poke up through the brown thatch of last year's dead weeds. A young cottontail rabbit, crouching in the tangle of blackberry brambles, samples the welcome leaves. His mottled brown coat blends beautifully with the dead grass. It is only as he turns to run away that his small white tail betrays him.

While many creatures are brilliantly colored, others have developed particular colors which blend in with their surroundings. For animals like the cottontail, survival may depend on not being noticeable.

One of the most interesting ways of hiding is for animals to seem to disappear. There are many ways to do this. Some creatures, such as certain fish, have leafy-looking growths on their bodies. Others have strange markings such as stripes and spots which attract the eye away from the shape of the animal. Some have colors which blend completely with the background.

Seeing a zebra in the zoo, one wonders how such an animal

can possibly hide. But the zebra is a particularly good example of what is called disruptive coloration.

The zebra's native habitat is the grassy plains of Africa. The sun beats down harshly—creating strong light and shadow. The distinctive black-and-white coat of the zebra blends with the swaying grasses. Thus, the outline of the animal disappears as the eye is drawn to the intricate details of its coat.

Another example of this coloration is found in the common meadow frog. Walk through a damp meadow in midsummer, and dozens of these little frogs will leap out in front of you. They seem to appear out of thin air. If you are quick enough to catch one, you will notice the markings on its skin. Various stripes and bars pattern its legs and body. When the frog is at rest beneath the marsh grasses, the eye sees only the spots and stripes—not the outline of the frog at all. Even the frog's eyes, which would be most noticeable, are marked by a stripe of pigment which breaks up their distinctive round shape.

A teacher once asked an art student why he had done nothing with the paper before him. "But I have," he replied. "Don't you see? It's a white rabbit in a snowstorm." This is not so funny as it sounds, for many creatures use this same technique for "disappearing." A green katydid on a shrub is completely invisible to the casual eye.

The praying mantis uses camouflage to catch numerous insects.

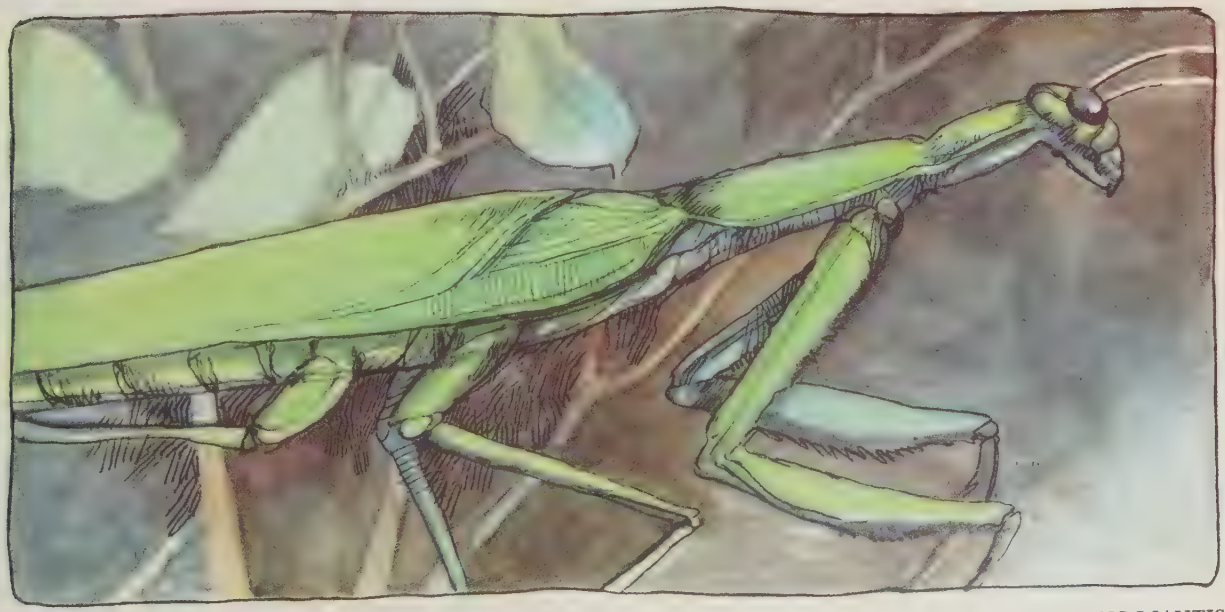
ZEBRAS

Swaying gently with the passing breeze, forelegs poised for the kill, the mantis waits silently. Its long green wings seem to be only another leaf on the shrub. But suddenly the "leaf" shoots forward as an insect passes within the grasp of the spiny forelegs. The disguise is cast aside. Almost as suddenly, a watchful bird swoops down to seize the mantis. Such an episode happens only rarely, however. For the disguise of the mantis is an excellent one.

Among the animals of the deserts, an unusual coloring pattern exists. All of these creatures tend to be lighter in color than their relatives which live in the lush, green, rain-fed areas. There are probably two reasons why these desert animals have pale colors. One is that these colors tend to make the animal invisible against the desert background of sand and gravel. The second is that light colors reflect much of the harsh sunlight and keep the animal cooler. Thus, animals with dark coats were easily seen and soon fell prey to some hungry predator. In addition, the dark colors absorb much heat and the animals sickened. Over millions of years, these and other factors eliminated the animals with dark coats.

However, other creatures which rarely come in contact with the sandy desert floor are also pale. The pallid bat, which flies only at night and spends the blazing daytime hours hidden in caves, is one such creature.

Some birds use a kind of disruptive coloration that hides their



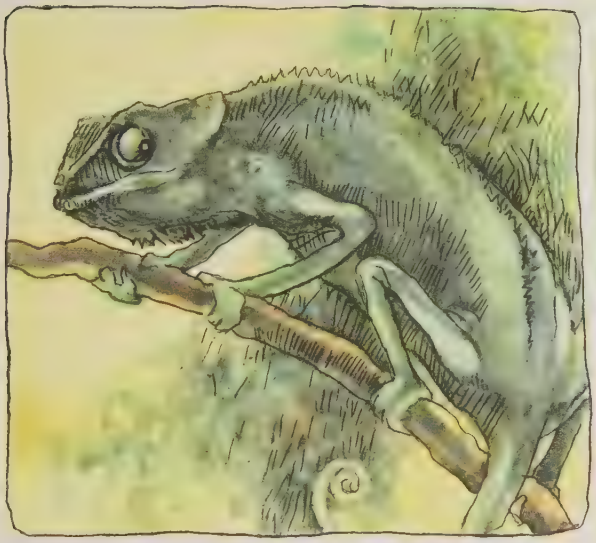
PRAYING MANTIS

nests. On the edge of a deserted gravel pit, a killdeer flies up in sudden alarm at the approach of a fox. Fluttering off, she helplessly drags her wings in an attempt to convince the invader she is injured. The fox, sensing an easy meal, runs after the bird. Not even for a moment is the nest noticed, though it is in plain view. The clutch of eggs nestled in a gravelly depression on the ground bear the same speckles and spots as the stones around them.

In the western Rocky Mountains is found a partridgelike bird called the ptarmigan. The plumage of these birds is so much like the gray speckling of the granite mountain that they are invisible even at close range. Thus, at the approach of a predator, these birds freeze and are almost undetectable.

The larva of the pine sphinx moth feeds on the long-needled

PTARMIGAN



CHAMELEON

TREE TOAD

scotch and white pine trees. It is green and striped lengthwise with yellow-green stripes. Against a cluster of needles, the larva looks like a tight bunch of needles. However, take away its protective background, and it is a very striking sight indeed.

But most amazing are those animals which are able to change their skin color to match different backgrounds. The tree toad, which is common in North America, does this readily. These small toads are found basking in various shade trees during the summer. Their peculiar cries are often heard during the warm weather. These creatures can change from almost pure white to deep brown, dark gray, or bright green. The color changes depend only on the object upon which the toad is resting.

The chameleon, of course, is one of the most famous animals which can blend its color to its background. It can do this because it has special pigment cells within its rough, scaly skin. By controlling the size and pattern of these spots, the chameleon mixes a blending of color. This color change is a reaction to heat, light, and the background color.

Fishes are also able to change color. Many times, this color change is really the result of the play of light on the fish's scales. Many fish can vary their colors to suit the shifting patterns of light

found in the sea. Sometimes, under stress, some fish will change color almost instantly.

Most mysterious of all are the color changes which the fiddler crab undergoes. Its color becomes darkest at night, during the period of low tide. At noon, during high tide, the fiddler becomes almost bone white. No one knows why they follow the rhythm of the tides almost exactly.

In the dense green jungles of Malaya lives a strange and gentle animal related to the elephant. The Malayan tapir might be one of the imaginary animals from the Dr. Dolittle books except that he isn't imaginary at all. He is a very portly creature, perhaps three feet tall, and weighing four hundred pounds. Because he is very gentle and unable to move in any great hurry, this animal is the favorite food of tigers, leopards, and wild dogs.

The coat pattern of some animals changes as the animal gets older.

MALAY TAPIR

The coat of the adult tapir is very strangely marked. The animal looks like an enormous black pig wearing a white blanket. But these markings protect the creature very well. As the tapir moves about in the jungle night, searching for food, the huge white patch stands out in the moonlight. The rest of the tapir is not so visible, because the eye of the enemy is drawn to the white patch. Thus, the enemy sees the patch, not the tapir.

The young tapir does not resemble its parents. Its coat is dark brown and marked with a neat pattern of stripes and spots. This coat also offers the protection of disruptive color. Snuggled on the floor of the dense Malayan jungle, or trotting about among the sun-speckled shrubs, the young tapir "freezes" at the first sign of danger. Thus, it blends into the background and seems to disappear from view.

WHITE-TAILED DEER

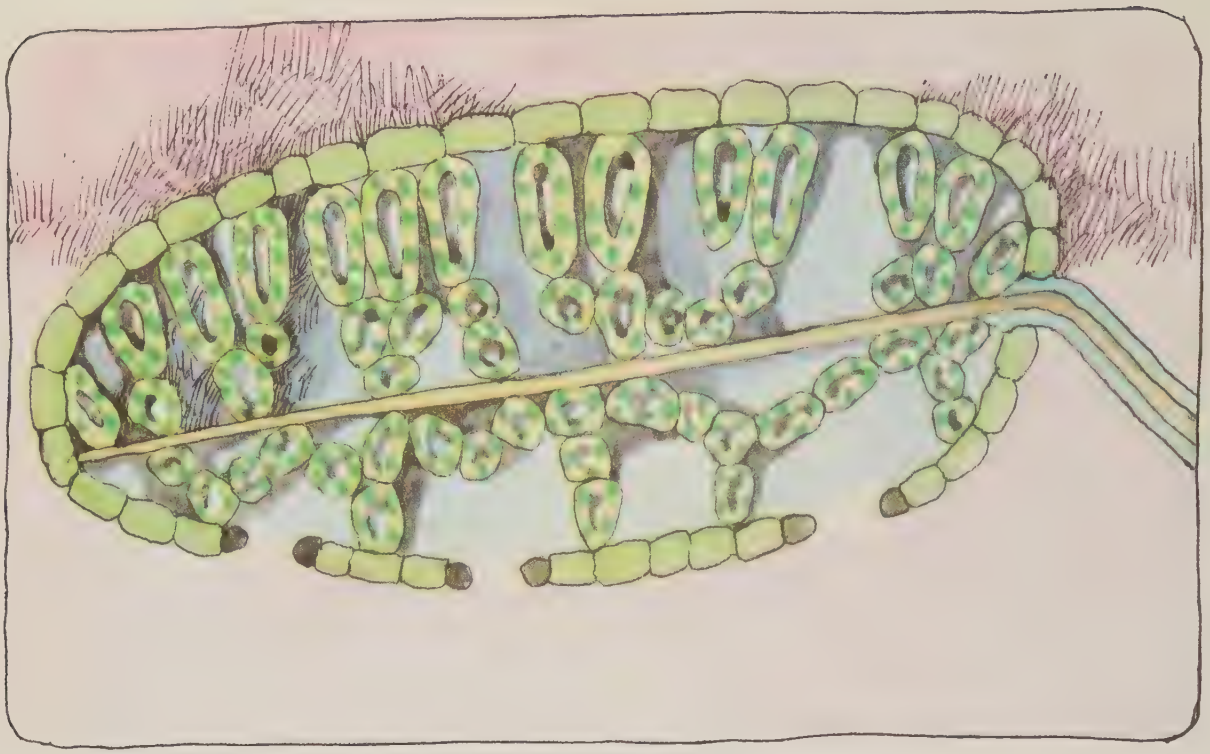
Chapter 4

The Green of Life

Millions of years before living things crept out of the sea and took up life on dry land, tiny plants grew in the ocean. Even today the upper layers of sea water carry billions of these tiny plants. Thus, the sea is a rainbow of color. Red, yellow, brown, and green plants tint the water in colorful profusion. These plants are called plankton, and without them the animals in the sea could not exist.

Each of these tiny organisms is a very efficient food factory. Using chemicals from the sea and light from the sun, they make food and release oxygen. These two things, food and oxygen, are essential to almost all other life. Scientists are not sure how these plants are able to do this. But they do know what happens during photosynthesis, as this process is called.

Most of these small plants contain a green pigment called chlorophyll. Not only does this substance give growing plants their green color, it causes the energy of sunlight to combine with the elements carbon, hydrogen, and oxygen. When these elements



Within the green leaf are chloroplasts where sunlight, water, and carbon dioxide are transformed into food.

are combined, they form compounds which are called carbohydrates. Carbohydrate is the chemical name for the food materials we call sugar and starch.

Stored in the carbohydrates is some of the energy of the sun. But this is not all that happens during photosynthesis. At the same time carbohydrates are formed, pure oxygen is being released. When the plant grows or an animal eats it, the carbohydrates are combined with oxygen and the energy is released. This energy is the power of life. Thus the humble, one-celled green plants produce two of the vital needs for life—energy-packed food to eat and oxygen to breathe.

Scientists know exactly what elements are contained in chlorophyll and they are able to make the magic green pigment. However, they still have not duplicated photosynthesis in their laboratories. So, almost all life continues to be dependent on the green plants that carpet the earth.

But the green life does not stop at the seashore. Look out over any summer landscape and the color that is always visible is green. Even in the driest climate, if one pulls away the dead brown leaves of any low-growing herb, there are young green shoots ready to spring up at the first rainfall.

However, the earth was not always green. Nearly four hundred million years ago, the first tiny, treelike plant raised its slender, spiraling branches. It did not look much like the trees we know today. Actually, it was much more like present-day ferns. At its tallest, this tree only stretched three feet toward the sun. It had no leaves, no needles, and no seeds. Photosynthesis was carried on in its bright-green bark, and this adventurous plant prospered. Reproducing itself with spores, just as ferns do today, it spread far and wide. Thus, this primitive plant was probably the first green vegetation to grow in large numbers on dry land.

Fifty million years after this humble beginning, green forests grew on the earth, with trees up to forty feet tall. These trees were the gilboa trees with fernlike leaves and trunks. They resembled today's palm tree. The gilboa's shape probably gave them greater stability in the shallow soil of the day. Like many primitive plants, they reproduced by spores.

For millions of years after this, the weather on earth was warm and tropical. Most of the continents were covered with great swamps where huge ferns, horsetails, and mosses grew. These green plants trapped the energy of the sun within their primitive leaves. And when they died, their remains became a rich soil that nurtured new generations of plants. Layers of decaying plant life were laid down in the oozing muck of these swamps. Many millions of years would pass before man would discover them.

Today, these ancient swamps are coal fields. They provide some of the energy man uses. So the energy released by the sun millions of years ago is now being used to heat homes and to manufacture and power modern machines. But this process did not go on only

in ancient times. Right now, photosynthesis is storing the sun's energy in the cells of plants. Today, as in the past, almost all the myriad forms of life that exist on earth are dependent on green

Forests such as this no longer exist, except as coal fields deep under the earth's surface.

plants for food. Even the tiger, which eats only meat, feeds on smaller creatures that eat plants. If green plants were to disappear from the earth, almost every other form of life would soon perish.

Chapter 5

The Red of Life

The sun brightens the spring landscape. In the arctic regions, the valley flowers burst forth with new life. But the mountain heights are still in the frigid grip of winter. Icicles still droop from the rocky ledges. The scene is one of stark grays and whites.

But now the sun has begun to melt the snow. The slight film of water on the surface glistens like a sheet of glass. A mountaineer coming upon this scene would be amazed—for the snow is not white but a bright pink!

The snow is white in color. But in that film of water on top of the snow are millions and millions of tiny plants. And on each of these plants is a bright-red spot of pigment. When millions of these plants are present, they tint the water red.

What this spot does for the plant is not known for certain. But it is believed that the red pigment shields the chlorophyll inside the plant from the intense glare of the sun.

The red pigment does the same thing for the plant as sunglasses do for us. We must have light if we are to see things. But too much light of the wrong kind will damage our eyes.

The plants must have the sun's energy to live. But too much of the wrong kind of energy will kill the plant. In the mountains, the sunlight has not been filtered through as much of the atmosphere as it has at sea level. It is very strong and contains types of energy that are not present in large amounts when the sunlight travels to the valleys below. Thus, to survive, the plants of the high mountains must have built-in "sunglasses."

There are many other plants that contain red pigments. The

A cover of scarlet tulips blankets this Dutch polder in the spring.

most obvious of these are bright spring flowers. Every year, sheets of crimson cover the Dutch polders in the spring. Millions upon millions of tulips, a large number of them in shades of red, are Holland's most famous export.

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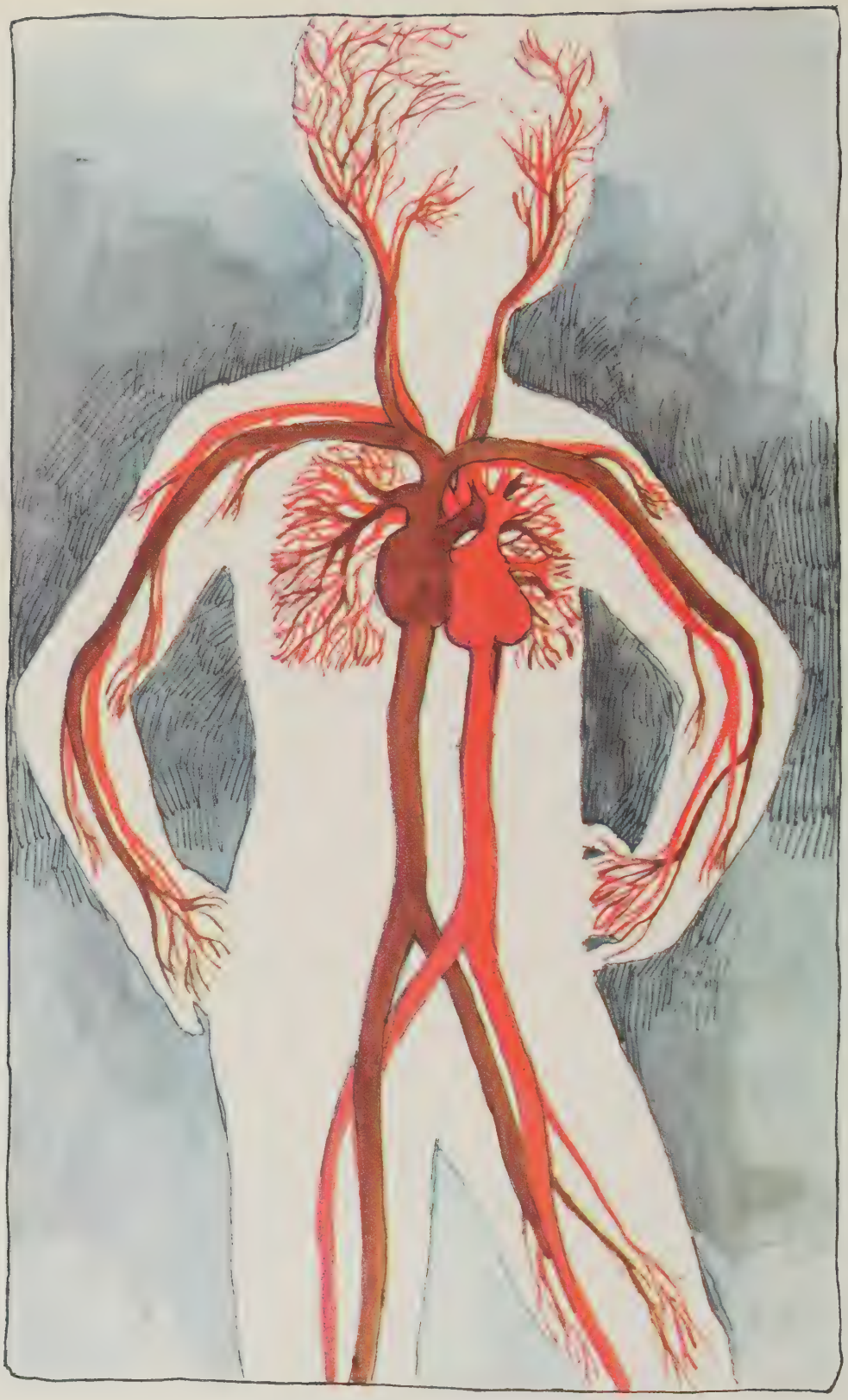
But even more common, although they are not as well known, are the red algae. Living in the sea, these plants contain a red pigment, phycoerythrin, that acts much like chlorophyll. Oxygen and carbon dioxide are removed from the water and, in the



Coursing through our veins and arteries, red corpuscles bring the breath of life to our cells.

presence of this pigment, combine with sunlight, forming food. Thus these plants, along with their green relatives, form the very foundation of life.

Red might be called the color of life. Inside our bodies, surging through our arteries, is that most vital of all fluids to humans—blood. And inside that blood are billions and billions of cells that contain a red pigment. In fact, these cells are so numerous they color the blood red. Actually, the liquid part of the blood, called plasma, is straw yellow in color. But the red blood cells are so numerous they cover this color.

The red pigment inside the red blood cells is called hemoglobin. It is given this name because it contains two compounds—a red pigment called hematin and a protein called globin. But it is the pigment that is of interest. It is red because it contains iron. This iron has a very important function.

As the blood circulates through the lungs, the iron combines with oxygen. This combination is a bright scarlet red and is very similar to the rust on iron objects that have been left outside.

Now the blood is pumped through the heart and out through the arteries of the body. As the arteries get farther from the heart, they branch out and get smaller and smaller. Finally, they are so small that they fit between the cells. When they are this small, they are called capillaries.

As the red blood cells pass through the capillaries, the oxygen that was picked up in the lungs is transferred to the cells. The cells combine this oxygen with food, and energy is released. This energy powers the cell. If the cell does not receive oxygen continuously, it dies in a very few minutes.

But what has happened to the bright-red color of the blood cells? It is gone and the blood is now a brownish red. Now the blood travels into the veins and back to the lungs where it will again pick up a load of oxygen and regain its scarlet color.

FLOWER MANTIS

Chapter 6

Counterfeit Color

The jungles of the world are noted for some of the most interesting animals on earth. But some of the strangest of these creatures go entirely unnoticed. Among the beautiful orchids of the southern Asian jungles lives an insect called the flower mantis.

Indeed, it looks exactly like a flower. Its colors are the same delicate pink as the orchid in which it hides. Its expanded hind legs resemble flower petals. And the stripes on the mantis' abdomen are identical to the stripes on the flower. Poised among the orchids, it waits in ambush for visiting insects. Its flowerlike colors hide the mantis from both its enemies and its prey.

What is much more amazing is the flattid bug of Kenya in South Africa. These insects flock together in little swarms. Most of them are a brilliant coral in color but a few individuals are green or have greenish markings. When resting, these insects gather on a bare twig or plant stem. Clustered together, they resemble some exotic flower—a hyacinth perhaps. Always the greenish individuals arrange themselves at the tip of the plant. Situated there, they

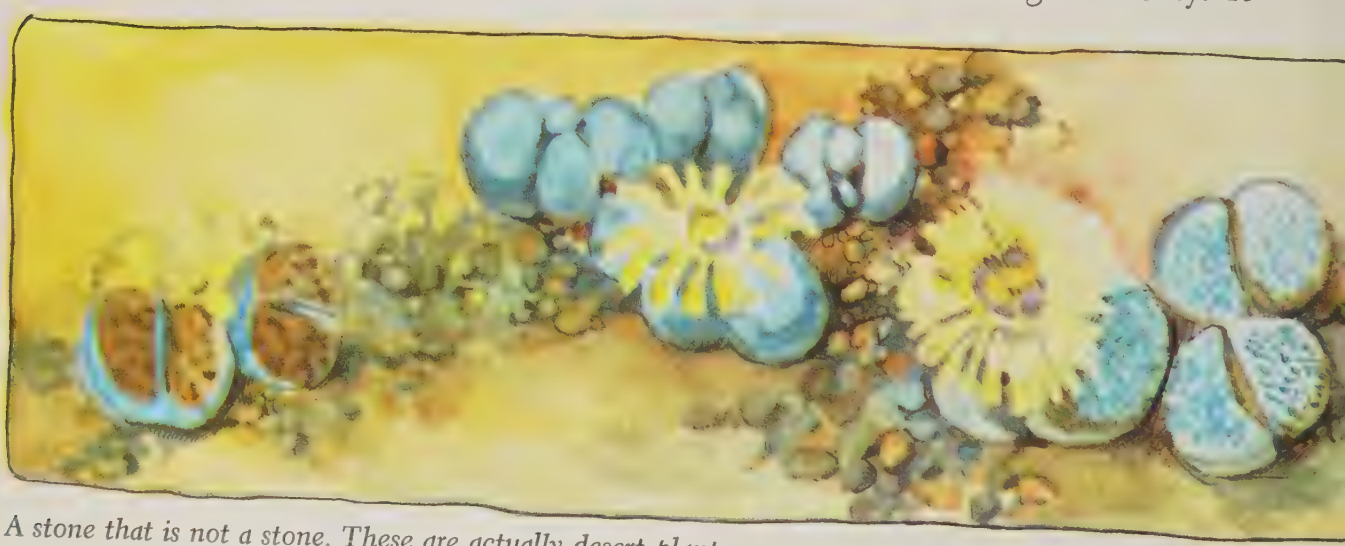
look like unopened buds. So realistic is the disguise that unless the insects are disturbed no one would guess they were not actual flowers.

Many other insects escape being eaten because their colors are like those of bees. The drone fly is one example of this. Humming about the garden flowers, the golden-brown insect seeks nectar along with the honeybees. Hovering above the blossoms, the fly's thick, fuzzy body and golden color can fool even the most critical bird.

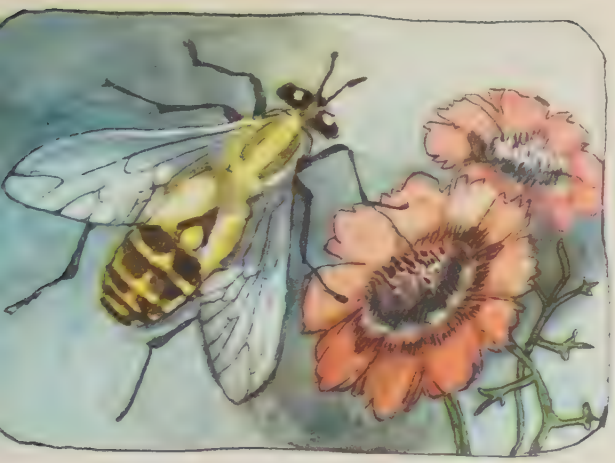
But the fly is not the only insect which mimics the color of the bee. Some moths resemble bumblebees. These are the bumblebee hawk moths, members of the sphinx moth family. These moths, like all others, have wings that are covered with brightly colored scales. But as soon as the bumblebee moth first uses its wings, the scales drop off, leaving the clear membrane of the wings exposed. The black-and-yellow stripes of the body, the clear wings, and the fact that this moth flies during the daytime, seems to convince even the hungriest birds that it is really a bumblebee.

Hurrying along on the forest floor is an insect that looks exactly like a large black carpenter ant. But it is really a long-horned beetle. This beetle's shape and color protect it. Most predators are familiar with the sting of the ant and leave the beetle well alone.

One of the strangest insect mimics is the caligo butterfly. It



A stone that is not a stone. These are actually desert plants.



EER FLY

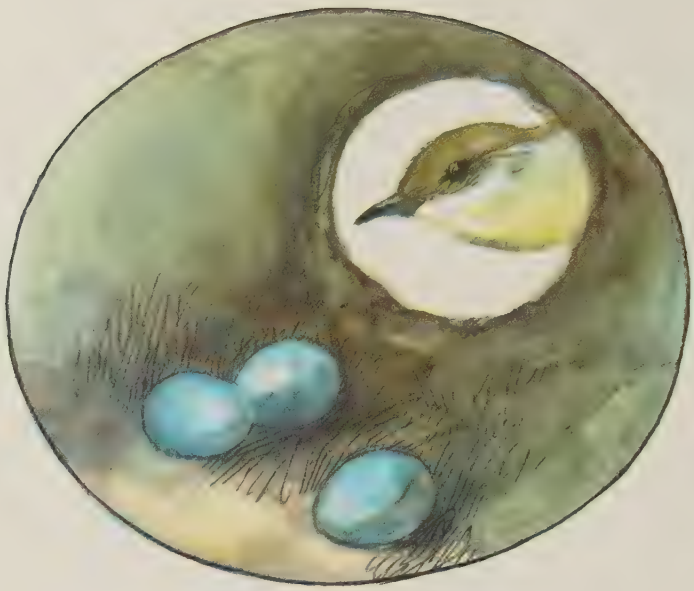
BUMBLEBEE HAWK MOTH

resembles a bird. Its wings are mottled grayish brown, and the hind wings display two round, golden "eyes" exactly like those of an owl. Hanging head downward on a limb, as the butterfly often does, it might easily startle a hungry enemy.

The orange-and-black monarch is a common butterfly in North America. The larvae of this butterfly feed on the bitter leaves of the milkweed plant. It seems that both the larva and the adult butterfly also taste bitter, for birds will not eat them.

The viceroy butterfly also lives in the same area. But the viceroy belong to a family of butterflies that are delicious—at least to birds. Except for a single black band in its wing, it looks almost identical to the bad-tasting monarch. Thus, to a bird, the viceroy is just another horrible-tasting monarch.

But it is not only insects which mimic other animals or flowers. Other creatures also disguise themselves in this manner. One disguise which should be handled with care by everyone is that of the scarlet king snake. These snakes look much like the poisonous coral snake which is found in the Southern United States. The king snake, like its deadly look-alike, is gaily banded in red and yellow. But unlike the coral snake, the bands of red and yellow are separated by a black band. The head of the harmless scarlet king snake is bright red. The coral snake has a black head followed by a yellow band. Very few people are tempted to come close enough to the snake to look for these details! The coral snake is one of the deadliest animals in North America.



An unsuspecting victim, this redstart will soon be a foster parent to a cuckoo.

In Africa, amid the harsh, dry landscape of the desert, are found some odd plants which look exactly like stones. They have round, fat leaves. Their color varies with the desert surroundings. They are usually grayish green. When the spring rains come, each "stone" blossoms with a delicate flower. But during the rest of the year they look inedible.

The cuckoo is a well-known bird in Europe. Unlike other birds, the cuckoo never builds a nest. Young cuckoos are hatched every year but they are never cared for by their parents. Instead, the cuckoo lays its eggs in the nests of smaller birds. There are several different species of cuckoos and each one lays its eggs in the nest of a particular host.

What is especially important is that the egg must look like that of the foster parents' own. For if it does not, it will be

speedily ousted from the nest. But the cuckoo lays eggs that are almost identical to those of the host. A Finnish cuckoo lays bright-blue eggs. These are usually laid in the nests of redstarts and winchats which also lay blue eggs. The greater reed warbler of Hungary lays greenish eggs with brown-and-black blotches. So do the cuckoos of the area, and they use the reed warbler's nest as a cradle for their own eggs. The deception is complete, for the warbler is unable to tell the cuckoo's egg from her own. She will brood the egg and care for the alien cuckoo nestling as her own.

Probably the most important law of life is to survive. Every wild creature is constantly faced by dozens of predators. The successful ones are those which avoid being eaten. Survival for some is based on strength. But for others it is simply looking like something you aren't.

FINNISH CUCKOO.

Chapter 7

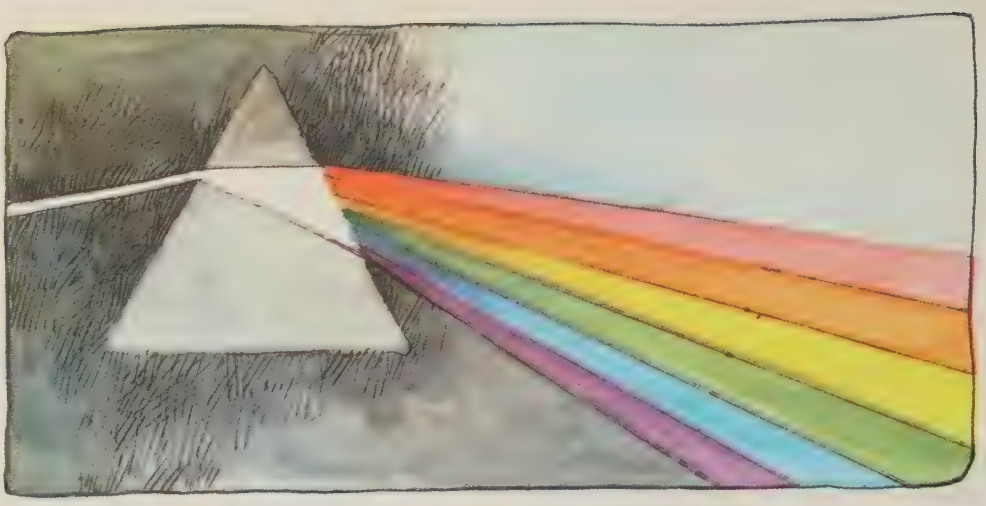
The Physics of Color

It is night and a chill wind whistles over the land. The green trees sway nervously and the bright blossoms of spring nod up and down under the force of the breeze. Clouds cover the moon and it is very dark. To a human being, the scene appears in very dim shades of gray and black.

But as the sun rises, the scene bursts into radiant color. It seems as though the colors disappeared during the night. And, in a way, they did disappear.

Color is caused by light. Or more correctly, color *is* light. Light is energy and, as with almost all energy on earth, comes from the sun. But the sunlight we see is white.

Many men have asked the question: How can white light cause color? One of the most famous of these questioners was Sir Isaac Newton. One day Newton was experimenting with a triangular-shaped piece of glass called a prism. Working in his laboratory, Newton made a dark shade with a pinhole in it. When he hung this shade over a window, it darkened the room and let one small beam of light pass through.



Sunlight passing through a prism is refracted into a spectrum.

Newton then placed his prism into the sunbeam. Observing carefully, he noticed that the beam was bent. But even more interesting, he noticed that the prism produced a rainbow of color on the opposite wall. When Newton removed the prism from the light, the color disappeared from the wall. All that was left was a white spot.

As he looked at the spot, Newton could see no color. Working carefully, he placed a second prism so that the light emerging from the first prism would pass through it. The light passed through the first prism, was again bent and emerged as a rainbow. It then passed into the second prism and was bent even further and made an even wider rainbow on the wall.

Newton started to rotate the second prism. Looking at the wall, he saw the colors get closer and closer together. Suddenly they melted together and the white spot reappeared. Newton began to formulate a theory that all the colors were in the white light. So what we see as white is a mixture of all colors.

Many men since Newton have been fascinated by color. Today we use their fiindings to explain why things appear to have color.

Most living things have chemical compounds in them called pigments. Pigments give these living things their color.

Suppose that a leaf appears green to us. This means that the pigment in the leaf absorbs all colors but green. Green is reflected back to our eyes. The same type of thing happens when

light hits a red leaf such as that of the Japanese maple. All colors of light except the red are absorbed. Thus, the leaf appears red.

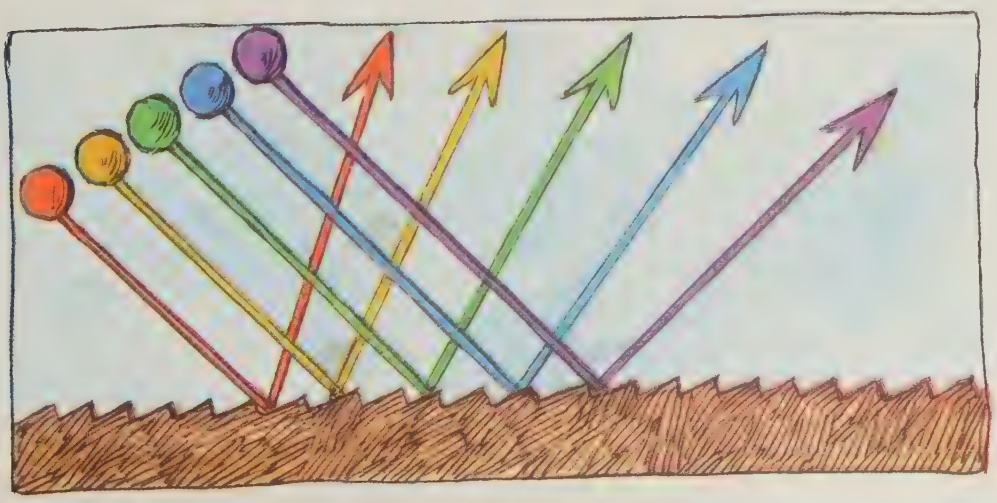
But this is not all there is to the color of living things. There are animals that change color as they move through patches of light. For instance, there is the shimmering color of the peacock as he moves through the shifting shadows under the trees.

Surprisingly, the actual color of a peacock's feathers is brown. The brilliant purple, the gleaming gold, and the shimmering green that you see as the peacock struts by is produced by something other than pigmentation.

When we bounce a ball off the wall of a building, the way that ball bounces depends on many things. It may depend on how fast we throw the ball, the angle at which we throw the ball, or how rough the wall is.

Light is, in many ways, very similar to this thrown ball. But white light is like many different kinds of balls thrown all at once. Each of these many balls has the same speed and hits the wall at the same angle. But each ball is slightly different, and when it hits the wall it bounces differently.

If we think of each of these different balls as representing a color, we can understand how the peacock gets its many hues. If the colors are rebounding in many different directions, only those colors that bounce toward our eyes will be seen. As the peacock moves, the angle at which the light hits the feathers will change slightly. Thus, the feathers will appear to shimmer and change color.



White light hitting a rough surface may be broken up into its component colors.

Chapter 8

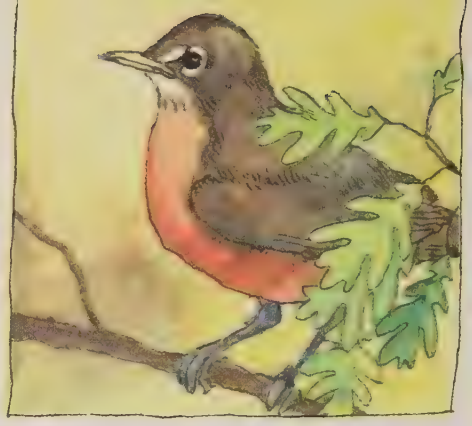
Changing Colors

Autumn sweeps across the land. The forests of the Temperate Zone glow brilliantly against the cloudless sky. Nowhere on earth, however, is the fall coloration of the trees as glorious as in North America. Europeans who visit New England in the fall find the sight unbelievable. Red maples turn bright scarlet, the birches a burnished gold, and the sugar maples orange. So beautiful is their color that a poet once wrote it shook him "like the sound of trumpets."

Everyone has heard the nursery tale that in the autumn "Jack Frost paints the leaves." What actually happens is much more interesting. In fact, the frost has nothing to do with the change in leaf color.

In late summer, the days grow cooler. The air is drier. The trees, which in summer may absorb a ton of water in a day, now use much less. At the base of each leaf stem, a layer of thin cells has been forming. Gradually this layer becomes thicker. But as the layer gets thicker, it becomes weaker and collapses. This plugs the cells which carry water and minerals to the leaf.

YOUNG ROBIN



ADULT ROBIN

The plumage of many birds changes with the season and as they grow older.

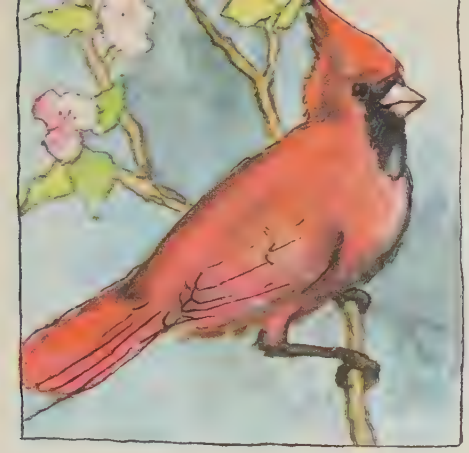
Now the green chlorophyll breaks down quickly. At last the other pigments within the leaf are visible. Some of these were there all along but the chlorophyll covered them up. Others are produced as the leaf dies and starts to decay. Red, yellow, and brown, these pigments produce the bright crown of autumn colors.

This wondrous display of color lasts only for a few weeks. Then, quite suddenly, the tranquil "Indian summer" landscape changes. The weight of the dead leaves is too much for the weakened leaf stems. The leaves break away and, within a very short time, most of them flutter earthward. Then the chill rains and winds of November send the last of them scudding to earth. The forest is now leafless and dormant, awaiting the season of snow.

Yet, within a few months, the sap will begin to rise in these trees. New buds will swell. By mid-May the forest will shimmer with a hundred shades of delicate, new green foliage. The green earth will renew itself in the light of the bright sun.

However, the trees of the forest are not the only life to undergo such seasonal color changes. Late in the summer, many of the birds go into hiding. At this time, they molt. When the new feathers grow in, they are often quite different than the bird's spring plumage.

In the fall, great flocks of bobolinks fly up from the meadows and travel to warmer climates. An inexperienced bird watcher might not recognize them. When the male bobolink arrives in



MALE CARDINAL, SPRING

MALE CARDINAL, FALL

the spring, he is easy to identify. Resplendent in black and white, he is unique. But in the autumn, his bright plumage is gone. Instead, he wears the same dull-brown feathers as the female.

And, in the fall, the young robins have lost their speckled breast markings. They have molted and now have plumage much like that of the adult birds. But, the winter plumage of the male robin is much duller, more like the female in color.

And the male cardinal's brilliant feathers are streaked with gray. Even the bluebird's feathers become duller. Nearly all the songbirds, in fact, become less colorful in the winter. Why this happens, no one really knows. Perhaps the bright spring plumage helps to attract a mate. But now the mating season is over and the dull colors offer better protection from hungry predators.

Animals, too, undergo seasonal color changes. The fallow deer, whose summer coat is spotted, grows a winter coat of plain gray-brown hair. The dappled summer coat offered excellent camouflage in the leafy forest. But in winter, it would only make the deer more noticeable among the bare trees.

The snowshoe hare of the north also hides within a new winter coat. Not only is it heavier, protecting the animal from cold, but it is white, matching the snowy forest. Such snow-white color is very necessary to the survival of the rabbit. For this animal is the favorite food of foxes, wolverines, owls, and wolves.

The champion of coat changers in the animal world is probably the weasel. It goes through several coat colors as the seasons

change. In October, the animal looks curiously spotted as the white winter fur grows through the brown summer coat. By mid-November, the weasel is almost snow white except for the tip of its tail—which remains black. Then in late winter as the days grow longer, the weasel will again change color. This time, dark-brown fur begins to come through the white. In April, the weasel looks like a white animal with a brown spot on its back. By summer, its coat, with the exception of a white belly and a black tip on its tail, will be dark brown.

Why do animals go through such color changes? Scientists think there are several reasons. Most of the seasonal changes in color are inherited. But if these inherited traits are to show up, the animal's glands must be stimulated. In regions where there are large changes in the amount of sunlight between the seasons, the animal's glands produce hormones which cause the animal to lose hair and to grow a new coat of a different color.

The southern relatives of these animals do not have to face the seasonal changes that northern ones do. For instance, the axis

FALLOW DEER, SUMMER

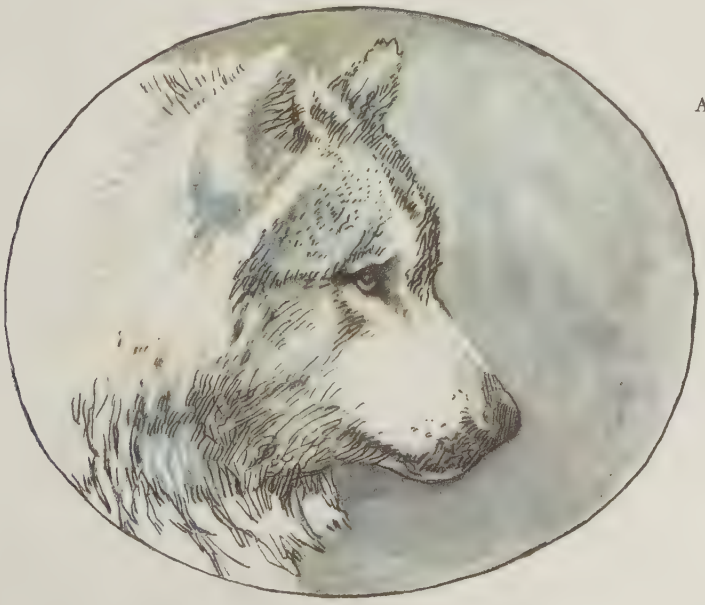
FALLOW DEER, WINTER

SNOWY OWL

deer of tropical Asia keeps its spots year round. In its habitat, there are no large seasonal changes and this coat hides the animal all year.

However, the southern relatives of the weasel do shed their summer coats for the winter. But their winter coats are always brown. And in the far north some animals keep their white coats all through the year. The polar bear, the arctic wolf, the arctic hare, the snowy owl, and certain caribou are white year round.

What probably affects the seasonal color change more than anything are the harsh laws of survival. Life in the world of nature is truly a battle to survive. Only those who are strong, those who are swift, those who are cunning, and those who are able to hide successfully are the ones who live to carry on the race. The adaptable live and life goes on.



ARCTIC WOLF

Chapter 9

The Biology of Color

More than one hundred years ago, an Augustinian monk named Gregor Mendel worked quietly in a monastery garden. From the time he worked in his father's orchards as a boy, Mendel had shown great interest in growing plants. For years he had been carrying on his careful scientific studies at the monastery.

Now he was eagerly awaiting the blooming of some pea plants. The summer before, he had put the pollen from a white-flowered plant on the flower of a redish purple plant. When the seeds were formed in the fall, Mendel carefully gathered and labeled them. In the spring he planted the seeds.

Because of his past studies, Mendel felt certain he could predict exactly what color the flowers would be. He predicted that they all would be redish purple. Imagine the puzzlement of the good monk when many flowers turned out not to be purple, but violet! Mendel was stunned. His predictions had always been right before. Was it some kind of trick that his fellow monks had played on him? Was all of the work he had done before worthless?

Like the true scientist he was, curiosity drove Mendel on to

more experimentation. He crossed two of the violet flowers. Then he collected the seeds from this cross and planted them the next spring. The following summer, the peas bore flowers of every shade from pure white to purple. Many of the colors had never appeared in his plants before. Now he was even more puzzled.

Mendel had believed that the redish purple color somehow completely dominated the white. Yet it could not be completely dominant, for the first flowers had been violet—a mixture of purple and white.

Now he began to fit missing pieces of the puzzle together. Perhaps in every plant there were several traits for color. Those with only purple flowers inherited only purple traits and those with white flowers inherited only white traits. Therefore, the plants with violet flowers had inherited both purple and white traits. This could also explain why the two violet plants produced offspring with such a variety of colors. They inherited differing amounts of purple and white.

Until Mendel's careful studies, no one had understood how colors or other characteristics were passed on from generation to generation. In fact it was not until nearly thirty-five years later that the work of Mendel was recognized by his fellow scientists.

Before this time, many scientists thought that inherited characteristics, such as hair color, were carried in the blood. So firmly rooted was this belief that even today expressions like "royal blood" or "gypsy blood" are common.

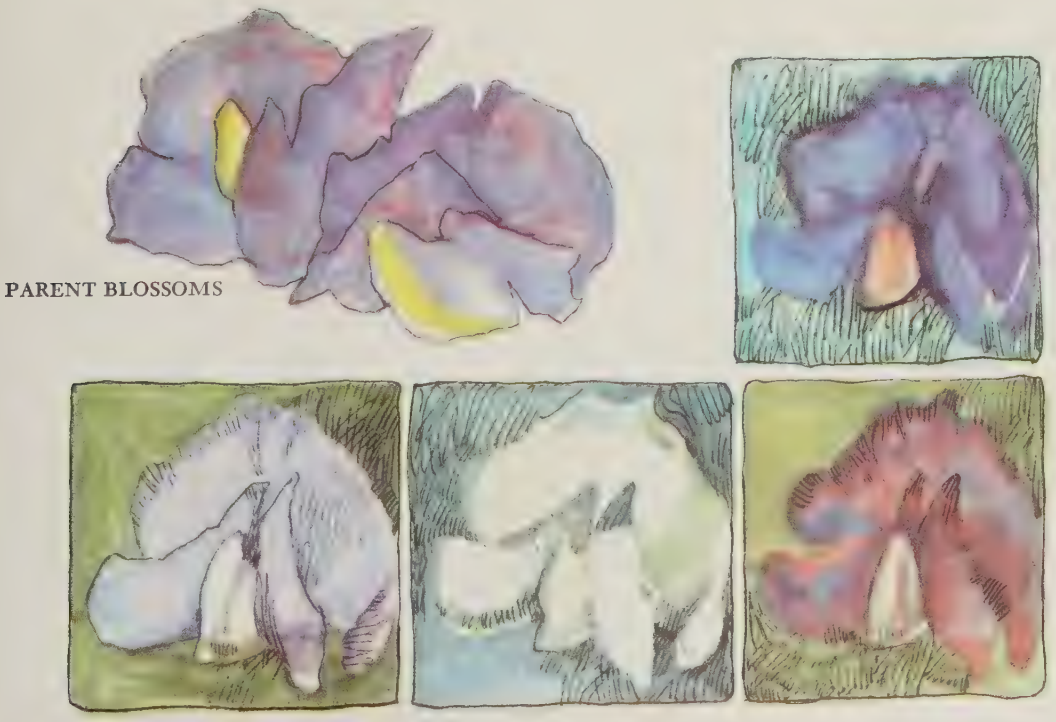
Almost fifty years after Mendel's studies, scientists found tiny bodies within each living cell which they called chromosomes. Under a microscope, the chromosomes appear as a series of slender threads. In reality, however, they are made up of many small units. Each of these small units is made up of even smaller units called genes. Each gene, along with others like it, helps direct the production of special characteristics. There are genes for hair color, for eye color, and for skin color as well as every

other characteristic that makes up a living thing. The higher forms of plant and animal life receive two sets of genes—one from each parent.

Mendel, in working with pea plants, found that some characteristics seemed to disappear. Some of the peas had green seeds; some had yellow. When he crossed the green and yellow plants, only yellow seeds were produced. The yellow color, he decided, was stronger than the green. It was not until 1915 that scientists gave names to the two types of genes. They called the stronger ones dominant and the weaker ones recessive.

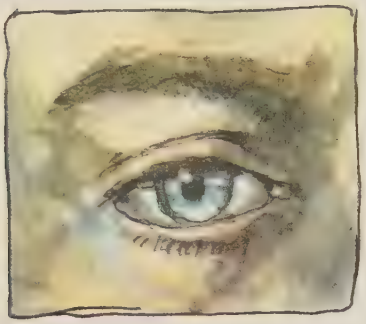
In the case of Mendel's pea flowers, some had genes for purple color only. These, of course, produced purple flowers. Some plants had genes for white color only. They produced only white flowers. But some had genes for both purple and white flowers. These produced the violet flowers because, in this case, neither the purple or the white gene was dominant.

Most of the time, however, one gene will be dominant over another. Eye color is one example. If both parents have blue eyes, it would be extremely unusual for their offspring to have any other eye color than blue. The gene for blue eyes is recessive. In order for blue eyes to show up at all, a person must



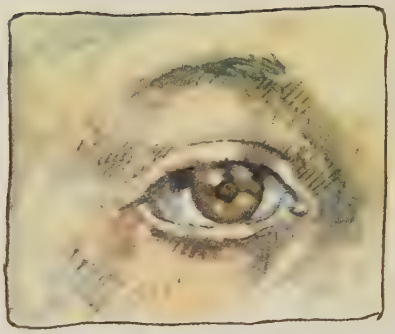
PARENT BLOSSOMS

OFFSPRING



BLUE-EYED PARENT

BROWN-EYED PARENT



BROWN-EYED CHILD

inherit two genes for blue eyes. Therefore, if both mother and father have only blue genes, the child will, of course, have only genes for blue eyes. The only exception to this rule would be if the child received a gene that had been changed. When a gene changes it is called a mutation.

However, a person may have brown eyes, although his mother has blue eyes. In this case, the person's father probably has brown eyes. The gene for brown-eye color is dominant, and the father's eye color has been inherited.

But in the same family, another child may have blue eyes. In this case, it is because the brown-eyed father carries one gene for brown-eye color but he also carries one for blue. Thus, the blue-eyed child received one blue-eye gene from her father and one from her mother.

Genes also determine skin pigments. Within the outer layers of skin are small cells called melanocytes. These cells produce melanin—a pigment which gives skin its color.

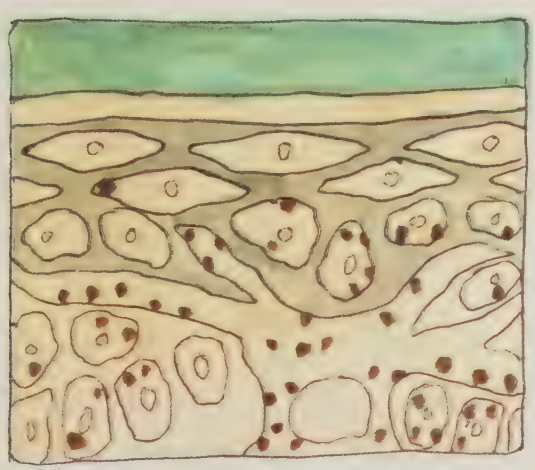
There are five distinct races of man on the earth. Each race has the same number of color cells in its skin. What causes the different skin colors is the amount of pigment that is produced and the way it is spread throughout the layer of skin. The color cells of the very blond person produce only a small amount of pigment. The color cells of a dark-skinned person, however, produce much more pigment.

The genes which produce skin pigments are dominant. But occasionally, an individual is born without any pigment in his skin. Such people are called albinos. They have snow-white hair and skin. Because their eyes lack the usual pigment, their tiny blood vessels make them appear pink. Even a little sunlight can cause dangerous sunburns on their skin.

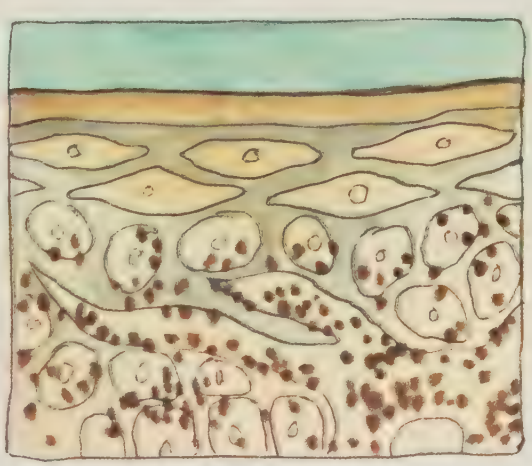
Albinos are found in every group of animals from fish to camels. The most familiar albino is probably the white "Easter" rabbit. Its white fur and pink eyes are typical albino characteristics. These traits are passed on by a recessive gene. Thus, to be an albino, an animal must receive genes for albinism from both its parents. For this reason, individuals with the traits are fairly rare. Among human beings, albinos occur only in one out of twenty thousand babies.

Since the time of Mendel, scientists have learned much about how traits are inherited. Gardeners have used this knowledge to improve many varieties of garden flowers. Farmers have used it to grow bigger and better crops. Thus, this knowledge has been used both to feed the world and to make it more beautiful.

No creature on earth delights more in the variety of beautiful colors about him than man. Many of the plants and animals he grows are grown simply to delight his eye. Perhaps, someday, he will learn that color in man himself does not make one person better than another.



NORMAL "WHITE" SKIN



SUN-TANNED SKIN

Sunlight can cause light skin to become darker. Sun-tanned skin contains much more pigment.

1. AFRICAN WOMAN
2. AUSTRALIAN ABORIGINE
3. SCANDINAVIAN MAN
4. JAPANESE GIRL

Chapter 10

The Color of Man

Why are there so many colors of man? This is a difficult question. There are probably many answers. Skin color, like hair and eye color, is inherited. There are numerous genes responsible for passing on skin color. That is why there are so many different skin tones. Even in a single family, one child may have extremely fair skin while another has darker skin. But there are also other reasons for the many different skin colors.

How did the human develop so many different skin pigments? Scientists think the first men lived in very warm climates such as that found in Africa. Only those who had dark skins were protected from the strong ultraviolet rays of sunlight. Those who had lighter skin were not as successful and, after thousands of years, they were no more. But this early man was a hunter and a wanderer. When he was unable to find game in the warm south, he began to wander north.

Here the air was cooler and the sunlight less intense. The dark skin which had protected him from harmful ultraviolet rays now screened out too much of the sun's light. Many people

developed rickets, a serious bone disease which makes the legs bow and causes curvature of the spine.

Over the hundreds of thousands of years that man wandered northward, the light-skinned man was better able to survive. His skin absorbed more of the ultraviolet rays. These rays caused vitamin D to be produced in the skin. Vitamin D prevents rickets. Thus, the black man did not survive in the north.

Climate seems to be a very important factor in the color of man. Even today, people who come from the far-northern regions of the world frequently have very light skin and fair hair. The Swedes and Danes are an example of this. The Eskimos, however, have rather dark skin. Scientists think that the Eskimo has not lived in the North very long. Thus, there has not been enough time for a light-skinned Eskimo to evolve. However, it may be that the Eskimo will keep his dark skin because he eats many fish which contain large amounts of vitamin D. Thus, having a light skin would be of no advantage to him.

People who come from warmer regions such as Central and South America and South Africa usually are brown-skinned. This is explained by the fact that too much vitamin D is almost as bad as too little. If the body produces excessive amounts of vitamin D, calcium and phosphorus are deposited in the soft tissues of the body, especially in the walls of the blood vessels. This causes high blood pressure and other illnesses.

And so, as man wandered across the continents of the earth, over millions of years, some people began to look quite different than others. Some people stayed in the warm, pleasant climate of the tropics. Sunlight warmed their rich brown skin.

Gradually, as the lighter-skinned people became fewer and fewer, almost all babies were born with darker skin. They did not develop such excessive amounts of vitamin D as did babies with lighter skin. Because they were better protected from the harsh sunlight, they were able to survive. Their children inherited

the protective brown skin. This is how scientists think the Negro race developed.

Other people settled in the cold, mountainous regions of northern Asia. They did not need the protection of very dark skin. Many of those who had dark skin may have developed rickets. Those with lighter skin survived because light skin enabled them to produce more vitamin D from the weak sunlight. Over the hundreds and thousands of years that these people remained in the harsh mountain country, they began to look quite different from their dark-skinned ancestors. These people had golden skin. People of this race are called Mongolians.

Another race of people probably developed in northern Europe. These people had to face the rigors of long winters. With the short winter days and lack of sunshine, only those who received as much of the precious sunlight vitamin as possible survived.

Today, most of the people of Europe have light skin. Many have light hair and blue eyes as well. Others have dark hair and eyes. They are all members of the Caucasian race.

Within each race are many other groups. And each of these groups is distinctive. Each has a beauty of its own. For instance, in Australia there is a very primitive group called the aborigines.

By the rest of the world's standards, the aborigines are a very scruffy-looking lot. But in motion they are one of the most beautiful creatures on earth. When running or throwing a spear, their fluid motion is beauty itself.

Thus, men, as do all other animals, come in many shapes and colors. But these are minor differences. Inside man is the same—the most intelligent creature on earth.

Only man has the power to destroy all life. And only he has the power to love, understand, and nurture all other life. Let us hope that color in man will come to be as the color in all other creatures—a source of delight and wonder.

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